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Executive Summary

The Common Object Strategy is a plan to evolve CADD and GIS standards information into a more real world environment using the emerging object.   The reason for pressing the Center's activities toward this direction is that object technology provides s a great degree of flexibility, control of large amounts of related data, and will facilitate interoperability among a number of disparate systems. Just as entity relational databases in the SDSFIE began to record the relationships of different but related categories of information, Objects will organize into classes real-world objects with real world functions instead of just recorded data.

The Object strategy paper is composed of the main body of the document, which provides the direction of how object data will be promoted by the CADD-GIS Center. There are also five appendices that divide this effort into many sub-categories of efforts toward the achievement of interoperability:

- Appendix A defines five goals of this strategy, the objectives of each goal, and the individual strategies intended to accomplish the objectives.

- Appendix B describes the background and concepts of Objects and provides the definition of the Center's usage and promotion of Standard Technology

- Appendix C contains a limited glossary of terms generally used in the object environment.

- Appendix D lists specific activities to be accomplished, with personnel and products identified, which will further the purposes and goals of this strategy document.

- Appendix E describes the rationale behind the Center's effort to promote object technology and information exchange using objects with a description of the near- term and long-term view of the approach.

The Center's Object strategy is a dynamic process that will be reviewed annually by the SWG on behalf of the Corporate Staff.

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Vision

The vision of the Board of Directors for the CADD/GIS Technology Center Consolidated Object Standards (COS) project is to enable the free flow, multi-directional sharing of object data and information between software packages, without duplication or loss of data content, structure, or semantics. The data will be fully attributed objects, whose state will be updated over time, dynamic, and reflect changing conditions based on process and natural phenomena.

Purpose

The COS Strategic Plan provides overall recommendations for the CADD/GIS Center for Facilities, Infrastructure, and Environment (the Center) Consolidated CADD/GIS/FM Object Standards projects using object technology. The strategic plan states the shared vision of Center leadership and management for developing and managing standards through the Center, defines the primary goals and objectives of using and migrating toward object technology, establishes measures of performance for all projects, proposes measured steps to accomplish the goals, and outlines execution plans for the Center's combined Standards approach.

The purposes of the COS projects are to improve data sharing, data volume leading to managed knowledge, and data security of current government AEC/GIS/FM business processes and all other future business practices involving facilities, infrastructure and environmental data which is dynamic and sensitive to changes based on process and natural phenomena. Current CADD and GIS documents contain a tremendous amount of information that is unavailable because of data transmission and translation difficulties. The Center's COS project will develop object data standards to enable the unrestricted use and exchange of data, independent of the application used to develop, update, or modify the data.

Scope

This strategy is linked to the Center's Business Plan in developing near term approach for applying object technology to the development and maintenance of standards for CADD, GIS, and FM data that will be recommended for adoption to developers of automated software products used to design, construct, operate, maintain and assist in the analysis of the Facility, Infrastructure, and Environmental (FIE) reporting responsibilities. The strategy includes goals for extending the availability of this data for other uses, for the management of the projects, technical aspects of the consolidated standards model, incentives to develop to be used by standards compliant products, collaboration approaches for work with other organizations, and goals for quality control. The strategy is product oriented to enforce relevance of the Center's approach to the needs of professionals such as architects, engineers, planners, environmental managers and facilities managers. The strategy is independent from any vendor specific technology or implementation.

This document also represents the Center's long-term approach for developing object standards. Data standards for engineering, object data and information software enable real-time data sharing between the engineering and management functions, between supplier and consumer, etc. Engineering and geospatial data standards are needed for Civil Works and Military operations. It is incumbent upon this effort to draw from the experiences, developments, and growth in other disciplines that process and conduct analysis on geospatial data, such as Modeling and Simulation (M&S) and Command, Control,

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Communications, Computers, and Intelligence (C4I), to refine the near and long term strategies of this effort

Management

The management of this strategy will be accomplished in accordance within the Center's Business Plan and annual budget process. The day-to-day administration of the tasks defined will be accomplished with the Center's staff or contractors. The SWG will review the COS at least annually, commenting to the Corporate Staff and Center on their findings and recommendations. The SWG shall review the execution of the COS in terms of technical accomplishments, execution of schedules, budget requests and strategic alliances. Based upon this annual review, the SWG shall make recommendations to the Corporate Staff and Center on changes, if necessary, to the scope, approach and alliances used to execute the COS.

Process

There are five main goals, or pillars, to support the COS strategic plan, which are detailed in Appendix A. The management goal is to optimize the object standard development process. Optimizing the standard process is expected to reduce resources needed to produce, adopt, and maintain standards. The technological goal is to anticipate technology capabilities now and in the next decade. This futuristic view will optimally position the Center's customers to take full advantage of the next generation technologies. The marketing goal is to improve adoption of Center object standards. Standards adoption is a critical factor to achieve the vision of interoperability. The facilitation goal is to collaborate with other organizations utilizing object data and information data, and leverage their existing and planned work efforts. Using others to facilitate standards design enables the government to leverage industry expertise while obtaining needed requirements in the standards. The quality goal is to establish and promote object standards compliance criteria. Standards compliance insures accurate understanding between software systems. These five goals are the foundation to meet this strategic vision.

Execution

The Center's past COS projects have made major contributions to the Industry Foundation Class (IFC) library for AEC CADD software systems, the AEC/FM software systems, and initiated object modeling of the Utilities GIS theme through the OpenGIS Consortium. In FY03, the projects will extend these efforts to include the GIS Transportation theme for Roads, Air, and Water, extend CADD Architectural objects through the International Alliance for Interoperability (IAI), and finalize the Utilities model for Potable Water, Waste Water, Gas, and Electric. Models from these themes will be consolidated to produce a formal consolidated object model containing both CADD AEC/FM and GIS objects.

The project goals, objectives, and strategies are enumerated and explained in Appendix A. Appendix B contains background information on object technology. A glossary of object technology terms is in Appendix C to incorporate commonly used terms in object technology. Appendix D contains information about activities to be accomplished in FY03. The execution plan and the overall project scheduling is outlined in Appendix E. All of the appendices will be revisited annually to assure relevance and currency. All appendices will be updated after the Corporate Staff has determined the final distribution of funds.

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Appendix A

Goals, Objectives, and Strategies

This appendix delineates the goals, objectives, and strategies that accomplish the vision. A goal is a long-term commitment of the Center to achieve a particular condition. The five goals are stated in their different perspectives. Objectives are major initiatives needed to achieve a goal. Activities are near-term or clearly identified activities that contribute toward meeting an objective. Activities will be modified over time to respond to current Center customer priorities and changing technology. Activity descriptions include the products expected from the activities. These products would be developed from Center projects.

Goal 1 (Management) Optimize Object Standard Development Process

This strategic goal establishes a technical management framework for developing and maintaining object standards in the CADD/GIS Center for facilities, infrastructure, and environment (FIE). This goal will modernize Center modeling techniques while maintaining conformance with DOD and Federal data standard requirements. The Center will replace its current standards modeling techniques with the Unified Modeling Language (UML) and will acquire COTS tools that facilitate management of standards releases and direct access from the Centers implementation toolset. The Center will integrate all standards modeling into the UML as the base model to facilitate CADD and GIS interoperability.

Objective 1.1 Extend existing Standards to Object Technology

The CADD/GIS Center has successfully developed standards for A/E/C CADD, spatial data, and facilities management using models for implementation. This approach is acceptable when GOTS products could be produced that augmented COTS products. In the next generation of standards, the Center will collaborate with partners in an electronic alliance that rely on interoperable COTS products. This objective will develop a single process to develop and manage standards development having a priority for standards incorporation into COTS products.

Activity 1.1.1 Consolidate Current Standards

To facilitate migration of the Center standards development process to an object technology, all current efforts of migrating entity-based standards to objects will be consolidated into one project within the Center's Core Mission projects. Mission Related projects using object technology will coordinate with the Core Mission projects and subscribe to the contemporary version of this strategy document. This provides a singular approach to the object efforts in the Center. Managers of Center projects will coordinate activities such that products of the core mission project will be implemented and used in products of the mission related project. The management structure will be a stable structure that will migrate to the technology that will replace objects.

The Center will develop a process of transferring technology to customers through the standards definitions and operational products. Standards implementing projects will document the success of implementing standards to produce a "lessons learned" database and a rationale for standards improvement.

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Activity 1.1.2 Use a Single Object Modeling Method

The Unified Modeling Language (UML) and Express-G are the popular modeling languages of standards organizations. The Center will use UML because data structure, object behavior, relationships, and metadata text can be stored in a singular tool. This preserves standards knowledge for review and analysis. A capable tool will be able to generate code for more rapid prototype development. The model will be in a form that can be migrated to the next technology. The UML diagrams Use Case, Class, and Sequence are the minimum set of diagrams for the consolidated model.

The Center will eventually manage consolidated standards using a collaborative approach and a consolidated modeling tool. At the same time standard objects will begin to contain standard functions that manage the data of the entity objects. The Center will identify individual Core Mission projects that will manage the maturation of standards. These projects may not be in the same form as current Core Mission projects due to the changing nature of the industry and the Center customers. The Center and Corporate Staff will propose these projects to the Board of Directors at the proper time to separate the effort. An individual of the Center staff will coordinate all object standards work.

The Center will acquire a modeling tool that supports incremental object model development. Projects will produce models according to themes (similar to entity sets in the SDSFIE). These themes will be a management tool for funding effort and measuring progress. The UML will be used to build the consolidated object model.

Activity 1.1.3 Consolidation of Implementation Tools

The Center will consolidate the tools used by customers to implement standards. The SDSFIE has successfully produced an implementation toolset for standards implementation. The consolidated object model will require extension of this toolset to produce implementations in future COTS technology. The nature of managing standards using a conceptual model will require a new set of tools to translate the object model into a form useful for the evolving SDSFIE toolset.

Activity 1.1.4 Provide draft standards to other domains

All object technology draft products will be provided to the FWG Object Focus Group for review and comment. The Object Focus Group will be expected to comment on drafts in order to minimize the impact on users when object technology is implemented.

Objective 1.2 Coordinate and oversee all Technical Products through product delivery.

The Center will produce products based on object standards conforming to this strategic plan. The Center web presence will be the predominate vehicle for knowledge dissemination its customers. The Center will supply a mechanism for knowledge access where subject matter experts will provide and maintain the content.

The Center has produced products that meet or exceed expectations of customers. All products need to have a criteria for quality that, when met, indicates that the product is ready for release. The following strategies concentrate on maintaining these criteria for product quality improvement.

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Activity 1.2.1 Improve Product Requirement Descriptions

Center project proposals will contain a list of deliverables and a description of each product. The Corporate Staff and the Board of Directors will then have a better understanding of the products of each project. The Center management will also have criteria for determining the status of the product for reporting purposes and determination of product release. References to existing written requirements will be encouraged to make the requirements description more concise.

Activity 1.2.2 Leverage work to benefit multiple products

Due to the nature of objects and their propensity for reuse, each Center project effort using objects is expected to contain potential benefits for other projects. Therefore, all Center projects will be analyzed by Center Staff to determine results that can be reused. Products produced by the Center will be available for reuse and the alliance of the Center with industry partners is expected to produce reusable results. Placing an emphasis on reuse is expected to improve the value of Center products while reducing unit cost and time to market.

Goal 2 (Technical) Minimize effects of Technology on Standards

This strategic goal establishes a framework for the technical production of object standards. Current Center standards were developed using a data modeling approach that is being replaced by object modeling. It is expected that object technology will someday be replaced by another technology. The object standards will need to be developed and maintained in a form that is divorced from the implementing technology to stabilize standards definition and minimize the effort to convert to the next technology.

A standards metadata model can provide this requirement for an overarching standards language. Changing the current entity-based standards to a metadata language will require a great deal of effort. Object modeling techniques provide a means to collect and maintain more standards metadata than the entity-based approaches. This strategic goal identifies areas needing concentrated effort to make standards models more robust in this dynamic technology age.

Objective 2.1 Reuse Legacy Models in Consolidated Standards

A significant step to preserve the effort on the SDSFIE is to consolidate the current standards into a single model. This new model will be an entity object model. This entity object model will contain the entity structure, entity relations, relationship cardinality, data dictionary, and rationale for data entities, data elements, and relationships. The final entity object model will contain the A/E/C CADD, SDSFIE, and FMSFIE models with no redundant information. This object model will contain the relationships between CADD entities, SDSFIE entities, and FMSFIE entities. These relationships will be valuable information when determining how to implement standards for customers.

Entity objects define and describe the data needed for the problem domain with little or no functional interfaces. Since objects encapsulate data and function, this initial integration of current entities into object modeling will be a baseline for additional work to identify and standardize object functions. This baseline will also be used to manage all new additions to the standards.

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Activity 2.1.1 Migrate Current Center Entity based Standards to Objects

Developing standards using this new technology requires a change in the formal process. The first step toward implementing this new process is migrating legacy information to the new technology. This operation will form the genesis of domain boundaries in the consolidated object model. The current SDSFIE and FMSFIE standards are expected to significantly overlap, i.e. have common entity objects. The AEC CADD standard is expected to have some overlap with the other standards.

Migrating current standards to object modeling requires
- Acquisition of a modeling tool that, as a minimum, can import existing entity models, create entity objects, augment these objects with functional interfaces, maintain model, object, and data element metadata, produce data models conforming to DOD and Federal requirements, maintain a single model having partitions for each domain model, provide multi-user operations, and provide configuration management of versions.
- Importing current Center standards models into the tool, reconciling differences, and identifying missing information.
- Importing current standards models produced by international standards organizations into the tool, reconciling differences, and identifying missing elements
- Proposing approaches to resolve the differences and supplying missing elements in the standards model.
- Proposing approaches to transfer standards to Center customers.

The methods for accomplishing the import, resolution of differences, and technology transfer should be accomplished through core mission and/or mission-related projects.

Objective 2.2 Develop Object Data Standards

The Center will use the work of industry partners to develop object standards for the Center customers. Development of standards requires a standards structure that enables progress measurement, product planning, independent theme definition, process management, version control, and quality control. The Center will create projects based on the structure of the consolidated object standards. These components will produce additions to the object model. Components will include products from Center work with other organizations, products from Center Mission Related projects, and products submitted from independent sources. Additions to the standards will be reviewed by Center personnel and added to the object model in conformance to the model structure.

Activity 2.2.1 Identify Areas needing Work

The consolidated object model developed in Activity 2.1.1 is not expected to be complete. There are expected to be areas that have been excluded from work due to constraints. These will be identified and documented as Lessons Learned in order to put the effort into the process for funding consideration.

Activity 2.2.2 Identify Areas Duplicated/Conflicting

Since the consolidated object model developed in Activity 2.1.1 will not be complete, the missing data and conflicting data will be identified and documented. Center personnel will analyze these anomalies and develop resolutions. Center representatives will present these resolutions to standards organizations and work with the organizations to resolve these duplications and conflicts.

Activity 2.2.3 Produce a Clean Initial Model

The baseline model produced through Activity 2.1.1 and updated through Objective 2.2 and Activity 2.2.2 should provide the information necessary to develop a full and complete baseline model. The model must be validated for complete compliance to the intent of the SDSFIE, FMSFIE, and AEC CADD standards. The result of this work will be a full and complete validated baseline model for all following object standards work.

Activity 2.2.4 Produce Standards from a Consolidated Model

To prove that the consolidated model developed in Activity 2.2.3 is a faithful representation for the standards, the entity-based standards must be derived from the model. Once the entity object model is developed with all duplicate entity objects and data element redundancy removed, a Center customer should be able to select the SDSFIE entity-based standard, the FMSFIE entity-based standard, or the AEC CADD standard from the entity object model. This operation is similar to the current tools used with the SDSFIE and FMSFIE standards.

Activity 2.2.5 Incorporate other Standards

The Center can integrate other object standards through Objective 4.1 into the consolidated model to identify conflicts and redundancy. Center participation with other standards organizations should facilitate the reduction of redundant standards development efforts, ultimately producing interoperable standards.

Activity 2.2.6 Integrate Data and Behavior

As the Center standards mature, objects in the consolidated model will be augmented with other objects and standard functions. These standard functions will mature from the obvious functions of drawing the object, storing values in the object, and getting values from the object, to the more useful functions like finding an item in the database, computing a design load, and finding a supplier for the item.

Since the Center and international standards organizations have not yet begun defining standard functions, this effort by the Center will be valuable to all standards organizations to indicate what behaviors would be in national and international standards. The Center will be a major player in national and international standards organizations to identify standard behaviors.

Objective 2.3 Manage Standards in a Metadata Language

A metadata language, like XML, is able to describe semantics and can describe the meaning of objects. Just as geospatial metadata adds value to geospatial data, object metadata adds value to object standards. Using a metadata structure the Center will capture the standards, models of the standards, version information of the standards, and the purpose of each item in the models of the standards. Having the purpose for an item in a model lends more meaning to the item and enables better communication between personnel about the models. This communication is imperative, as the Center becomes a collaborator with other standards organizations. A metadata model abstracts the original object model to a level that will be transferable to the next technology.

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Activity 2.3.1 Define a CADD/GIS/FM Interoperable Data Language

The AEC CADD community has developed means to share data between CADD software. The IAI has successfully developed an object class library that shares information between software products. The OGC is developing standards for data interoperability. GDL is an open language from Graphisoft that can be used to transport object data. These interface formats infer knowledge that is not explicitly contained in the files. A model containing this knowledge will benefit future standards efforts by documenting past knowledge to future practitioners. Integrating this knowledge, through the operations of Activity 1.1.2, enables the model to serve as a knowledge base of engineering information. To preserve this knowledge from technology changes, the model language must not be closely tied to software implementation.

This strategy does not suggest development of a new computer or modeling language. This strategy states that the Center will use a language for all standards models that supports interoperability. To date, the language of choice is the Unified Modeling Language (UML) due to its relative maturity and support through automated tools. Other languages may need to be considered and compared with UML. The Consolidated Object Strategy project emphasis is to integrate object products. Just as engineers need automated tools for analysis and design, the Center needs automated tools for consolidation, analysis, and design of standards. The tools must be interoperable and conform to the requirements identified above.

Activity 2.3.2 Produce Standards Documents from the Object Model

The consolidated model will be developed to become a consolidated object model. Augmenting the object model will enable other engineering domain standards to be defined. This approach enhances standards quality by producing an interface for the extracted object standard. Interfaces are essential for software interoperability and provide software developers access to standard objects used in their applications.

Objective 2.4 Maintain Consolidated Object Standards

Maintenance of consolidated object standards will require maintenance of the integrated detailed conceptual AEC/FM and GIS models. The Center will maintain a singular repository that consolidates its AEC/FM and GIS standards. This repository will be the basis of all toolsets developed for AEC/FM and GIS implementations. Individual conceptual models will be maintained by the standard organization but the Center will maintain a consolidated model in UML form or as an interface between the individual standard models.

Activity 2.4.1 Maintain Standard as a Detailed Conceptual Model

The standards will be maintained as a detailed conceptual model. The conceptual model will include all object classes with their attributes, behaviors, and relationships. The model is considered conceptual due to the lack of implementation constraints. Over time the model will become an ontology that can assist customers with CADD/GIS implementations and data conversion due to technology changes.

Activity 2.4.2 Provide Tools that Produce an Implementation Model

The Center will develop a toolset that converts the conceptual model, or portion thereof, to a form that can be implemented. The product of this toolset is an implementation model similar to the current SDSFIE.

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Activity 2.4.3 Provide Tools that Implement the Standard

The Center will leverage the development of the SDSFIE tools to produce the implementation tool set. It is expected that these tools will consist of a tool set that extracts selected portions of the standard and another toolset, similar to the SDSFIE toolset, which creates an implementation of the standard for the customer.

Activity 2.4.4 Provide Tools that Upgrade Implementations to New Standard

Since the standard is in a conceptual model, the Center will be able to develop a new toolset that assists the customer to upgrade their implementation to the current standard. The user will be able to use this toolset to maintain compliance with the standard and maintain their individual enhancements to the standard.

Activity 2.4.5 Provide Tools that Retain Customer's Legacy Data

The Center will produce a toolset that enables a customer to convert their legacy data to a new version of the standard, a new enhancement of the standard, or a new database. The use of ontological technology enables the use of data semantics to manipulate data elements without losing content. This toolset will allow the customer the ability to augment the standard and remain compliant.

Goal 3 (Marketing) Promote Center Object Standards

This strategic goal establishes a framework for promoting the adoption of object standards by automated engineering tools vendors and the use of object standards by government agencies. Use of the SDSFIE, FMSFIE, and A/E/C CADD standards are varied. The A/E/C CADD standard is compliant with the national CADD standard that is expected to become an ISO standard. The SDSFIE is now an ANSI standard.

We expect that the Center standards will be useful to organizations that demand interoperability. Object standards will also satisfy interoperability demand through software function in a multiprocessing operating system like Microsoft Windows 2000 or UNIX and its derivatives (e.g., Linux). Object standards will also reduce software development cost through software reuse. Since object standards are directly implemented through software languages, vendors are expected to implement the standards rather than burden the user community to implement standards.

Objective 3.1 Deliver Standards to Customers using Implementing Software

Government and industry have developed automated engineering tools. Due to the unacceptable life-cycle cost of internally developed software, the government has adopted an acquisition policy placing a preference on COTS software rather than GOTS software. This policy is expected to distribute development costs over a wider market making unit costs less expensive thereby saving the government money. This objective addresses this policy by striving to integrate standards into COTS software.

Success of this objective is dependent on the success of Goal 5 (Establish and Enforce Object Standards Compliance Criteria). The COTS software vendors will need to implement standards consistently to insure the benefits of interoperability. COTS software vendors will be encouraged to implement object standards in their automated engineering tool products.

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Activity 3.1.1 Include COTS Vendors in Standards Planning

The COTS software community has not eagerly adopted standards that were developed without consulting COTS software manufacturers. The IAI had difficulty attracting adoption of early standards by COTS software manufacturers due to the expense of changing internal code to comply with the new standards. When COTS vendors are included in the planning stage of standards development, they provide valuable insight into the needs of the market. This insight has the benefit of early adoption of the standards by COTS software and eager customers who desire the new functionality of the software.

Object standards planning will include COTS software developers. Software vendors supplying products to CADD, GIS, and FM customers will be invited to participate in discussion to determine priorities for object standardization.

Activity 3.1.2 Solicit COTS Vendors' Comments to Draft Standards

Just as COTS software developers are valuable in the planning of standards development, they are just as valuable in providing comments to draft standards. Draft standards provide developers an early view of standards. COTS software developers will alert the standards team when the draft standards would cause an unacceptable investment to implement.

The COTS software vendors will be invited to participate in reviewing and commenting on draft standards. Their comments will be seriously considered and will be adopted except when the comments are clearly self-serving or create conflicts within the model. It will be the burden of the project manager to show clear reason to ignore comments from a COTS software developer.

Objective 3.2 Promote Enterprise Tool Interoperability through utilization of COTS Software

As COTS vendors introduce compliant automated engineering tools, the Center will promote the use of these tools. Promotion will occur though the operations of the Center with customers, training, and products of mission support projects.

Activity 3.2.1 Use Compliant COTS Software in Training Courses

When possible, the Center will demonstrate and use standards compliant software tools in all training courses. If COTS software is not available that complies with accepted Center standards, Center instructors will alert students of the deviations from the standards in the products used in the course and demonstrate limitations encountered when not using standards compliant software.

Activity 3.2.2 Deliver Products that use COTS Compliant Software

The Center will deliver products that require use of standards compliant software tools. Mission related projects would deliver products to customers. All products will be developed using standards compliant software and will require use of compliant software for product maintenance.

Activity 3.2.3 Demonstrate Compliant COTS Software

The Center will demonstrate the benefits of using standards compliant software tools for visitors and at conferences. Limited time demonstrations will use compliant software only.

Objective 3.3 Produce and Maintain Contract Language Requiring Use of Object Standards

Acquisition of COTS software by government agencies is controlled by procurement regulations. Acquisition of COTS software by government contractors is influenced by the same regulations. The intent of this objective is to influence these regulations to make interoperable software acquisition easier and encouraged.

Activity 3.3.1 Develop Contract Language Requiring Compliant COTS Software

The Center will develop language that can be included in contracts that requires use of interoperable software compliant with industry standards. These standards will be those that incorporate object standards.

Activity 3.3.2 Incorporate Language Requiring Compliant COTS Software into Standard Contracting Processes and Contract Paragraphs

The Center will coordinate with procurement offices to incorporate language that encourages use of COTS engineering tools compliant with object standards.

Objective 3.4 Admission and submission of Standards to International Standards Bodies

The Center will maintain membership in relevant standards organizations. The Standards Working Group and the Object Focus Group will make the determination of relevance. The Center will work within these standards organizations to facilitate and organize projects that advance, promote, and maintain object standards.

The Center will develop materials for submitting government requirements to national and international standards bodies. As a member of standards organizations, the Center will work to lead prominent committees and workgroups. The Center will offer government work to date as baseline material for these standards organizations to use in development of standards in a particular theme.

Goal 4 (Partnering) Collaborate with other Standards Organizations

This strategic goal establishes a framework for partnering and collaboration between the Center and other government agencies, industry, and academia. The approach uses the Center as a focal point for communication between object standardization efforts and federal organizations to gather federal requirements, enter these requirements into the object standards process, evaluate draft object standards and their impact to the federal processes, disseminate completed object standards, and participate in the compliance programs. The Center will be the organization that receives concerns by the users. These concerns will be incorporated into all object standards projects to affect the standards. Adopted standards will be incorporated into products by vendors.

Objective 4.1 Facilitate Collaboration between Standards Organizations

The Center core mission efforts for developing object standards will collaborate with recognized standards organizations. This collaboration will take the form of active participation in defining standards

to develop, leading the definition of standards, providing technical analysis of developed standards, and supporting the compliance programs. These associations will expose the Center to the software vendors who will incorporate standards into their products in support of Objective 3.2.

Currently, AEC, FM, and project management domains are standardizing objects through the IAI. GIS/geoprocessing technology interfaces and geospatial data access are being standardized through the OGC. Some FM object standards efforts are being accomplished through the Facility Maintenance & Operations Committee. Business and "simple" standards are being developed through the aecXML group. The national CADD standards are coordinated through the National Institute of Building Sciences using American Institute of Architects, Construction Specifications Institute, and the Center as technical developers.

Activity 4.1.1 Establish Committee Chairs in Standards Organizations

The Center will be an active member of standards organizations by volunteering for chair positions of technical committees. Center object projects will leverage the work of other members in these standards organizations at the expense of delivery time.

Activity 4.1.2 Maintain Activity in IAI

The Center has been a member of the IAI for several years and helped develop the new standards development process now used in the IAI. The Center will continue to be a leader in the IAI by continuing to chair domain committees and participate in projects. The Center may need to assume additional leadership roles in the IAI if interest wanes by other government organizations.

Activity 4.1.3 Increase Activity in OGC

The Center will be an active member in the OGC to influence object standards for GIS/geoprocessing operations. COTS GIS/geoprocessing vendors and other geospatial software developers recognize the OGC as the predominant standard organization for this technology area and are adopting their standards. There has been no active presence of the Center in OGC. In addition, there has been little work on developing object standards in the OGC. (However, the OGC understands object standards for the FIE and other domains are necessary.) Additionally, USACE joined OGC in part to coordinate the work and interests of USACE and the Center within OGC.

Activity 4.1.4 Identify other organizations

Additional associations will be added as they emerge in the standards community. There are over 3000 standards organizations that affect automated life cycle engineering tools. Most of these organizations are waiting for major standards organizations to develop standards. The Center will limit active object standards development participation to those major standards organizations that are actively developing standards.

Objective 4.2 Facilitate Vendor Object Designs and Implementations

This objective enforces Center efforts toward a preference of COTS implementation in lieu of government software development. This will be successful if and only if the COTS implementation fully satisfies the government's requirements. These requirements are embedded in the object standards.

Activity 4.2.1 Produce a Prototype Project to Implement a Consolidated Standard

The Center will collaborate with COTS software developers to produce a prototype system demonstrating successful consolidation of entity-based standards into entity object entities.

Activity 4.2.2 Establish a project in OpenGIS to prototype a consolidated approach.

The Center will become an active participant in the OGC and will obtain OGC adoption of a project. The project will begin the definition of GIS objects and establish the foundation for follow on work.

Goal 5 (Quality) Establish and Enforce Object Standards Compliance Criteria

This strategic goal establishes a framework for compliance certification of object standards implementation in automated engineering tools. Once object standard compliant products are available to users government productivity will be enhanced by the use these compliant software in future projects by government and contractor personnel. These products will be used in all phases of the project. Therefore, all personnel (government and contractors) will need to use compliant software products. The Center will coordinate with all its customers to encourage government personnel to use standards compliant software. The Center will also coordinate with its member organizations to ensure contracting offices incorporate proper language causing contractors to use object compliant software. The result of this task will directly improve the electronic commerce operations of the federal government.

Objective 5.1 Establish and enforce compliance criteria

Standards require compliance and the ability to show compliance. The Center will participate in the development of standards compliance tests and evaluation of COTS products against these tests. Hopefully, in most cases this will be in conjunction with the standards development organizations. A compliance program requires establishment of the test cases that determine compliance, a facility to execute the test cases, a means to identify compliant products, a means to describe compliance, aspects of liability, and a means to improve over time. The Center's object projects will focus their contributions towards compliance programs that directly support Center standards. Use Compliance Criteria Programs of other organizations

Compliance standards and execution of compliance programs can be a costly endeavor. To reduce the cost of evaluating product compliance to object standards, the Center will partner with industry standards organizations to influence their compliance programs and augment industry compliance testing with only those tests necessary for specific government compliance requirements. An example of government compliance that industry would not necessarily include would be tests of government only operations or structures (e.g., levees, dams, and secure operations).

Activity 5.1.1 Participate In Developing Compliance Standards In Standards Organizations

As an active member of industry standards organizations the Center will participate in the planning, design, and execution of the organization's compliance program. These programs will evaluate automated engineering tools for compliance to current standards. There may be several levels of

compliance, i.e., minimum, average, or exceptional. The Center will influence development of compliance tests to include government compliance requirements.

Activity 5.1.2 Participate In Executing Test Cases For Standards Compliance

The Center will participate in evaluating automated engineering tools for compliance. Compliance criteria will include both industry standard compliance and specific government standards compliance. It is expected that costs to perform these tests will be borne by the standards organization or the software development organization.

Objective 5.2 Model Center Criteria after other organizations

Specific government compliance criteria will be modeled after the criteria developed by industry standards organizations. This approach assists the Center to demonstrate augmentation of industry standards without duplication. In the event that no industry standard compliance exists, the Center will develop compliance criteria to assist the industry.

Activity 5.2.1 Determine Government Compliance Criteria

The Center will help the standards organization develop compliance evaluation measures. Procedures to measure compliance will be developed by the standards organization. The Center will develop compliance evaluation measures that are unique to the government and will develop procedures to measure compliance using these criteria.

Activity 5.2.2 Conduct Government Compliance Tests

Using the procedures developed in Activity 5.2.1, the Center will negotiate time and funding for conducting compliance evaluation tests with organizations developing automated engineering tools. These tools must first be evaluated by the industry standards evaluation criteria.

Objective 5.3 Design and Trademark a Symbol

A trademarked symbol will be adopted by the Center to signify compliance with government object standards. The symbol will be displayed on the product packaging and software operation. It will be a visual marker showing the product compliance with government standards. There may be different levels of compliance. The product symbol will identify the version or date of the object standard

Activity 5.3.1 Design a Symbol Signifying Government Compliance

The Center will develop a symbol that can be trademarked signifying compliance to government object standards. The symbol will be referenced in contract language for easy identification.

Activity 5.3.2 Collaborate With Other Organizations To Leverage Compliance Testing

The Center will not be the sole evaluator of automated engineering tools for the government. Other government agencies, i.e., Department of Energy, will be solicited to assist in developing compliance criteria and participate in evaluation testing.

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Appendix B

Object Technology

Historical Perspective

Database technology shaped the desire and need for electronic data sharing. In the twentieth century, all people needing access to that kind of data shared data for a particular business function. Personnel having a need to know accessed the data through applications specifically written for the database structure. The emergence and popularity of the Internet made information available through browsers. Still, special software has to be written to enable access to particular databases having a known access and a known structure.

Data now needs to be accessible by anybody having a need for the data to accomplish their task or business function. An international exposure to a database creates issues in data structure, data quality, and data security. Object technology is an attempt to meet the challenges of data structure.

This appendix is an overview of the usefulness of Object technology for data sharing. The next section contains a general overview of Object technology. Each concept will be described and then be illustrated using a general illustration and a illustration from the CADD/GIS/FM disciplines.

Properties of an Object

Object technology is a general term that refers to the concept of perceiving the world as individual objects. Each object has a three-part structure. Each object has a **name** that is unique to the object. For example, the family pet has a name, like Fido. This name is unique to that object. Another example is the office door. It may have a name like *8000Door1245*, indicting that office 1245 has a door in building 8000. Notice that the object name is as simple or as complex as necessary for the domain of all objects.

Each object has characteristics that distinguish it from all other objects of the same type. These characteristics are called **attributes**. These attributes contain values that describe the object. The family pet named Fido has a color, has a birth date, has a particular sound, and has other characteristics that are important to the pet owner. The above door object has a color, has a swing direction, has a hinged side, etc. Notice that the object attributes are a collection of characteristics that are useful to the person interested in knowing about the object.

Each object is able to act and react in its environment. The actions of the object with respect to the environment are called **operations**. Operations change values of attributes, provide information to another object, or trigger an operation in another object. The family pet can make a sound. This action of making a sound would be modeled and implemented as an operation of the object Fido. The door can be shut. The shutting of the door would be modeled and implemented as an operation. All operations have an expected condition of the object before performing the operation and an expected condition of the object after performing the operation.

A collection of objects that have the same operations and the same kinds of attributes are grouped together as a **class**. A class is an abstraction of this group of objects. A class has its own name. It describes all the operations common to all objects that are derived from the class. A class specifies the attribute types that each object derived from it will use to store the object's unique value. The family pet

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named Fido is an object of the class Dog. Therefore, Fido can do all the operations of the class Dog. Fido's color attribute contains a value representing "brown". The particular door of the office is of the class Door. It swings open. The attribute for swing direction has a value that means the door " swings into the office". It is important to think of objects as things that exist and think of classes as a model of a group of things that exist.

The last concept of object technology covered in this appendix is how objects and classes interact. Interactions or influences between objects and classes are called **associations**. One aspect of object operations was that an object can cause a change in another object. This interaction is an association between the two classes. There are many different association types in object technology. The association type often represented in object-oriented training is the generalization/specialization association. This association describes a hierarchy of one class to another. The family pet dog is a member of the Dog class, which is a member of the more general class Mammal. The office door is an instance of the Door class which is a member of the more general class Closures. These hierarchies are means of grouping classes together so that common attribute types and operations are modeled once. Many other associations are used in Object technology diagrams to describe the different degrees of influence the objects derived from one-class exhibits on the objects derived from another class.

Object Standard Diagrams

Many different methods of object modeling have been developed since object oriented programming became popular in the last decade. The defacto standard approach is the Unified Modeling Language (UML). The UML is standardized by the Object Modeling Group (OMG). Additional information about the OMG and the UML specifications is located at URL http://www.omg.org.

A standard will minimally consist of UML class diagrams. This diagram will resemble an entity-relationship (ER) diagram but will show class inheritance and class operations. These were shown on an ER diagram because the diagramming syntax did not have the provision. A UML class diagram is a static diagram that displays classes, their names, attribute types, operations, and associations. Additional diagrams display dynamic characteristics of the classes. A well-defined standard will include UML Use Case diagrams, UML Activity diagrams, and UML Sequence diagrams. The UML Sequence diagrams will be limited to the standard sequences that occur between implemented objects.

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Appendix C

Glossary

Introduction

The glossary refers to terms used in this document that may not be familiar to the reader. All terms are defined from the perspective a strategic document where the audience is intended to be managers having a wide range of experience other than the technical domain of object oriented computer science.

Definitions

Term	Description
Abstract	A higher class that does not have an implementation (i.e.: Mammal Class: There are no "Mammals" without being a member of a lower subclass: dog, whale, dolphin, mouse…).
Aggregation	An abstraction in which relationships are treated as higher level relationships; relationships among relationships Ex: the Aggregate Entity Set of 'BORROWER' includes the Entities & Relations for CUSTOMER & LOAN
Application program interface (API)	A formalized set of software calls and routines that can be referenced by an application program in order to access supporting system or network services. An interface that applications use to offer services and communicate.
ASP	Application Service Provider. A service provider that hosts applications and enables companies to outsource specific applications, processes, or transactions for a subscription or per-transaction fee.
Association	In data modeling, an association is a structural relationship that specifies that instances of one things are connected to instances of another.
Attribute	A name↔value pair that represents a Object information or properties "wall: concrete"
Behaviors	The set of actions that an object is responsible for (can) exhibiting when it provides a specific service.
Class	A description of objects with identical attributes, common behavior, common relationships (associations), and common semantics.
CGI	CGI Script (common gateway interface script) A small program, written in a language such as Perl, which functions as the glue between HTML (hypertext markup language) pages and other programs on the Web server. CGI scripts have been the initial mechanism used to make Websites interact with databases and other applications. However, as the Web evolved, server-side processing methods have been developed that are more efficient and easier to program.
Comment	An item in an XSLT style sheet that contains extraneous information. Written between the delimiters.
component	Represents software that provides services. Components can be shipped and deployed independently, and they have their own release cycle.
Concept phase	the initial phase of a software development project, in which the user needs are described and evaluated through documentation (for example, statement of needs, advance planning report, project initiation memo, feasibility studies, system definition, documentation, regulations, procedures, or policies relevant to the project).
content management	The process of capturing content, normalizing the disparate entries into a standardized format, hosting the content, and continually updating the content to reflect the latest product additions, modifications, or deletions.
COS	Common Object Schema (COS)
Document Element	The outermost element of a document. The Document Element contains all of the other elements. Contrasted with the root node.
Domain analysis	Activity that determines the common requirements within a domain for the purpose of identifying reuse opportunities among the systems in the domain. It builds a domain architectural model representing the commonalities and differences in requirements within the domain.
Domain design	Activity that takes the results of domain analysis to identify and generalize solutions for those

Term	Description
	common requirements in the form of a Domain-Specific Software Architecture (DSSA).
Domain engineering	The process of analysis, specification, and implementation of software assets in a domain which are used in the development of multiple software products [SEI 96]. The three main activities of domain engineering are: domain analysis, domain design, and domain implementation.
Domain implementation	Activity that realizes the reuse opportunities identified during domain analysis and design in the form of common requirements and design solutions, respectively. It facilitates the integration of those reusable assets into a particular application
Domains	In a database, the set of allowed values for a table column, for example all positive integers. Examples of domains are Project Management, Design, Schedule, and Plant.
DSL	A technology designed to bring high-bandwidth information to homes and small businesses over ordinary copper telephone lines. A DSL signal can be separated so that you can use your telephone and computer on the same line at the same time.
DSS	Domain Specific Schemas: Each domain owns one or more schema namespaces and each namespaces can have one or more schemas. Numbers of the namespaces and schemas depend on the demand and are assigned by the aecXML Committee. Examples of domains are Project Management, Design, Schedule, and Plant.
Element	A logical element within an XSLT style sheet delimited by starts and end tags.
Enterprise asset management (EAM)	Evolving from CMMS (computerized maintenance-management systems) EAM applications not only manage the physical maintenance of a company's equipment or construction machinery but may extend to all conceivable assets including intellectual assets such as plans and blueprints, back office records and documents, and even human resources.
Enterprise resource planning (ERP)	An integrated information system that serves all departments within an enterprise. An ERP system can include software for manufacturing, order entry, accounts receivable and payable, general ledger, purchasing, warehousing, transportation and human resources. Major ERP vendors are SAP, PeopleSoft, Oracle, Baan and J.D. Edwards.
Entity Classes	Conceptual classes generally used for long term persistent information These classes are not technically complete but contain enough behaviors and attributes to demonstrate the automation of a business process.
Expression	A construct that can be evaluated to a string, number, Boolean, or set of nodes. Expressions are used in many contexts such as the select attribute of the element.
Extensible Markup Language (XML)	The universal format for structured documents and data on the Web, which is increasingly becoming the general standard document format of structured data.
Extensible Stylesheet Language Transformation (XSLT)	A specification for transforming XML to XML, HTML, or other document types. The language used by XML style sheets to transform one form of an XML document to another.
extranet	A controlled, private web site that allows controlled access for authorized outsiders. An intranet resides behind a firewall and is accessible only to people who are members of the same company or organization, an extranet provides various levels of accessibility to outsiders. An extranet can only be accessed with a valid username and password with the user profile determining which parts of the extranet can be viewed. Extranets are very popular means for business partners to exchange information.
gateway	A generic term for software/hardware that accepts or generates messages using protocols or standards such as xCBL, BizTalk, RosettaNet, and EDI.
Generalization	An object-oriented means for implementing hierarchical domains where inheritance is the predominate relationship between objects.
Generic Security Services Application Programming Interface	The application level interface (API) to network security systems. GSS API allows the integration of security functions that are available from an external security product, such as strong authentication or encryption.
GeoDatabase	An object-oriented geographic database that provides services for managing geographic data. These services include validation rules, relationships, and topological associations. A GeoDatabase contains feature datasets and is hosted inside of a relational database management system.
HTML	A "Document type definition" (DTD) that specifies a finite tag set for marking up documents. The tag set is presentation specific (i.e. headings, paragraphs, fonts), focusing on formatting characteristics more than attempting to model any particular information set.
IF	Implementation Framework (IF)
Interface	Collection of named operations provided by a class. The information that must be published by an object in an automation that enables another object to correctly request a service.
Interface engines	Applications that provide connector devices between two systems, they are used to intercept, transform, and queue messages for delivery to the next application

Term	Description
interoperability	The ability of a system to interact with systems from other vendors. Typically interoperability is made possible be each system's adherence to industry standards and the principles of open architecture. Interoperability can exist between buying and selling applications as well as e-marketplaces.
intranet	An internal Internet. An intranet is a network based on TCP/IP protocols and belonging to an organization, usually a corporation. An intranet is accessible only by the organization's members, employees, or other authorized users. An intranet's web sites look and act just like any other web site but the firewall surrounding an intranet fends off unauthorized access. Secure intranets are now the fastest-growing segment of the Internet because they are much less expensive to build and manage than private networks based on proprietary protocols.
LandXML Site	An interoperable XML data format used for Civil CADD data. LandXML-1.0.xsd
Messages	A request for services sent from one object to another. See behavior.
messaging	Process of information transfer among services on separate components based on document exchange.
Microsoft .NET	Platform from Microsoft for XML Web services; includes tools to develop and deploy Web-based applications.
Model	An approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system. Note: Models may have other models as components.
Namespace	A named collection of names. A namespace is named by using a URI, to ensure uniqueness, and utilizes a preface to provide context for elements and attributes.
Node	An object of a tree structure.
OASIS	Organization for the Advancement of Structured Information Standards, a non-profit, international consortium that creates interoperable industry specifications based on public standards such as XML and SGML.
Object	A specific instance of a class. An object is uniquely identified by a unique identifier.
Object Class	An abstraction of similar objects. See Class.
Ontology	Taken by itself, it may seem that there is not much difference between ontology and a data dictionary. However, a data dictionary is typically just a compendium of terms together with definitions for the individual terms stated in natural language. By contrast, the grammar and axioms of ontology are stated in a precise formal language with a very precise syntax and a clear formal semantics (see Section 4.2). Consequently, ontologies are, in general, far more rigorous and precise in their content than a typical data dictionary (and, hence, more so than a typical data "encyclopedia," because an encyclopedia is just a collection of related data dictionaries). Ontologies also tend to be more complete as well: relations between concepts and objects in a domain, and constraints on and between domain objects, are made explicit rather than left implicit, thus minimizing the chance of misunderstanding logical connections within the domain.
Open	An architecture or system that is open to working with technologies, applications, and data from other systems; uses a standardized data format that all interfacing systems can access. Refer to interoperability.
operations	An often used synonym for behavior. See behavior.
output method	XSLT defines three output methods: XML, HTML, and text.
pattern	A construct that defines a condition that every node either satisfies or does not satisfy. Used as XPath expressions in XSLT elements.
portal	An information system allows the organization, management, and presentation of information through a single access point (or portal). Information does not have to be stored in a master repository, rather these systems will provide facilities to locate, process, and deliver the information to a requesting agent
property	A synonym for attribute. See attribute.
repository	Used to store and look up shared metadata and information. In this context, repositories store information on interfaces, process descriptions, and logical components at design time.
result tree	The output of a style sheet. A style sheet defines a transformation from a source tree structure to a result tree structure.
root node	The highest node in a tree structure. In a well-formed XML document, the root node will have exactly one element node, representing the document element, and no child nodes. It may also contain comment nodes and processing instructions nodes as children.
schema	A schema provides a way to do a lot of the basic declarations possible in XML, but makes the declarations easier to both read and write. The declarations contained in a schema enable a structured way of containing data. Vocabulary Model written in the syntax of the specification language.

Term	Description
Service	The implementation of an interface by a component. It represents an executable entity. For the caller or sender, a service is a black box that may require input and delivers a result.
Simple Network Management Protocol	SNMP is a set of rules that allows computers and wired devices to communicate with each other via a common syntax of shared data-compression standards, among other technical minutiae
Simple Object Access Protocol (SOAP)	A lightweight protocol for exchanging information in a decentralized, distributed environment. It is an XML-based protocol that is typically used with HTTP. It includes conventions to represent method calls of objects or function calls and the respective responses, as well as conventions to represent standardized data types.
Taxonomy	Taxonomy a scheme that partitions a body of knowledge and defines the relationships among the pieces. It is used for classifying and understanding the body of knowledge.
Template Body	A sequence of XSLT instructions, HTML tags, and text forming the contents of an element.
Template Rule	An element with a match= attribute. A template rule may be invoked by using the instruction.
Tree Structure	An abstract data structure representing the information content of an XML document. The tree structure always has a single root.
UDDI	Universal Description, Discovery, and Integration. UDDI is a project to design open standard specifications and implementations for Internet service architecture capable of registering and discovering information about businesses and their products and services.
Universal Discovery Description, and Integration (UDDI)	The UDDI project is a sweeping industry initiative to create a platform-independent, open framework for describing services, discovering businesses, and integrating business services using the Internet, as well as an operational registry, which is already available today.
UNSPSC	Universal Standard Products and Service Codes. A ten-digit, five-level categorization scheme developed through the merger of the United Nations Common Coding System (UNCCS) and Dun & Bradstreet's standard products and services code (SPSC). UNSPSC is an emerging standard recognized worldwide.
URI	Uniform Resource Identifier: a generalization of the URLs (Uniform Resource Locators) used to uniquely identify resources such as addresses on the Internet.
URL	Uniform Resource Locator, the global address of documents and other resources on the World Wide Web. The first part of the address indicates what protocol to use and the second part specifies the IP address or the domain name where the resource is located.
value chain	An expansion of the supply chain concept. The value chain is the sum of all linked vertical operations that an organization uses to create value in the form of products or services.
vertical	Markets can be defined as horizontal or vertical. Vertical markets are targeted at single industries and integrate multiple roles and functions within that industry.
web server	A computer that delivers web pages. Every web server has an IP address and possibly a domain name. The server fetches the page and sends it to your browser. Any computer can be turned into a web server by installing server software and connecting the machine to the Internet.
well-formed	A document is well-formed if it follows the syntax rules in the XML specification. These include such rules as there must be a single outermost element that encloses all other elements and all start tags must have closing tags.
wrapper class	Class designed to provide an existing application an Object Oriented interface.
XDK	XML Development Kit.
XML	A subset of the Standard Generalized Markup Language (SGML) published by the International Standards Organization in 1986 (ISO 8879). There is often a lot of confusion regarding the relationship between SGML, XML, and HTML. XML differs from the Hypertext Markup Language (HTML) in that HTML is an SGML application. XML (just like SGML) is a meta-language for specifying structured document interchange over the web
XPC	XML Portal Connector.
XSL	Extensible Stylesheet Language (XSL) Consists of two parts: the transformation language and the formatting language. (XSL transformations equivalent to XSLT). XSL is primarily used to define the format and presentation of XML documents.
XSLT	XSLT provides syntax for defining rules that transform an XML document to another document. (For example, to an HTML document.) An XSLT 'style sheet' consists primarily of a set of template rules that are used to transform nodes matching some patterns. XSLT style sheets consist of a series of template rules and commands used to select and manipulate the structure of the data. The combination of both the XSL and XSLT provides a display template for an XML document.
XSTL	Extensible Style sheet Language Transformation, a specification for transforming XML to XML, HTML or other document types.

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Appendix D

Schedule of Activities in FY03

The Object Focus Group met September 12-13, 2002. One of the products of the meeting is a concise list of activities to be performed in FY03 and the resources designated to those activities. This appendix lists these activities and explains the intent of the group.

Update the Strategy Document

Required resources: David Johnson, Jack Huntley, and Warren Bennett

Specific instructions: The Strategy Document needs to be updated and modified to reach a wide audience. The subgroup will modify the document to place the vision at the beginning of a short, no more than five pages, and document body. The document may have appendices that contain detailed information. As a minimum the appendices will contain a glossary, an explanation of object technology, an FY03 Execution plan, and the full set of strategy goals and objectives. The sub group may add other appendices as they think are needed to communicate the material to government and industry readers.

Strategy support: Objective 1.2

Expected product: this strategy document

Expected end date: 31 October 2002

Continue Support of the IAI (4.2

The Object Focus Group determined that the IAI performs a vital role in developing AEC CADD object standards. Many vendors who have formed the Building Lifecycle Information Systems (BLIS) have adopted the IFC. BLIS coordinates adoption of IFC releases to synchronize delivery of interoperable software from the various software developers. The Group determined that the following three initiatives are to be funded in FY03.

Lead the IAI Facilities Management Domain Committee

Required resources: Dave Horner

Specific instructions: Mr. Horner will continue to lead the FM Domain Committee of the IAI. The FM committee will initiate a project that coincides with the FMSFIE efforts and identify mechanisms in the IAI to conduct projects with IAI industry partners that demonstrate CADD and GIS interoperability. The FM Domain will complete requirements for Portfolio and Asset Management - Performance Requirements (PAMPeR). This project will define the performance requirements and planning of capital projects or improvements that meet the needs of the owner or users. Information used in typical business processes by owners and users to define what is required and to assess whether what is required is being or has been provided will be identified and defined.

Strategy support: Objective 3.1 & 4.1

Expected product: Express G Model of Portfolio and Asset Management.

Expected end date: Sept, '03.

Lead the IAI Project Management Domain Committee

Required resources: Francois Grobler

Specific instructions: Dr. Grobler will continue to lead the Project Management Domain Committee of the IAI. The PM Domain will create a link between the specification of materials/products and the IFC model in a way that "plugs" electronic product information gathering and procurement directly into design, construction and FM information. Work will be coordinated with the Facilities Management Domain on the PAMPeR project and will be compatible with the OmniClass specification (developed from Masterformat, Uniformat concept)..

Strategy support: Objective 3.1 & 4.1

Expected product: No specific product identified for FY03.

Expected end date: No date is specified.

Participate in the IAI Architecture Domain Committee

Required resources: Toby Wilson

Specific instructions: Mr. Wilson will become a participant of the IAI Architecture Domain Committee and contribute government AEC expertise and standards to the committee. Mr. Wilson will encourage the Architecture Committee to endorse, adopt, or effect change to other AEC standards such that the IAI IFC incorporates best standards from other industry and government agencies.

Strategy support: Objective 3.1 & 4.1

Expected product: No specific product identified for FY03.

Expected end date: No date is specified.

Lead effort with the IAI to expand the IFC to a point of connection between the IAI and OGC information

Required resources: Dave Horner, Francois Grobler, David Johnson

Specific instructions: The IAI and OGC will be asked to develop a document outlining variations between the GML and the IFC and IFCxml data to identify communication, transformation issues between the two formats. Mr. Horner will also coordinate with the IAI organization and members of the IAI to determine and initiate work that will connect with the Utilities Object model and the SDSFIE utility information currently being used as an ANSI standard.

Strategy support: Objective 3.1

Expected product: An analysis/description of the task involved in interoperability between what is normally considered CADD data contained within the IFC and the GIS data to be contained in GML. An accepted IAI project to extend the IFC to include the utilities to a point of connection with GIS information will also be created. Work to be coordinated with the OGC Utilities model and SDSFIE data model.

Expected end date: Summer 2003

Test CADD/GIS Interoperability

Required resources: Jack Huntley, David Johnson, Warren Bennett and Francois Grobler

Specific instructions: The Center will participate in an initial collaborative effort with the IAI and with ESRI to create/read/write IFC information for a limited amount of building and topography entities. The objective will be to develop an interface between the IFC Object information and GIS software. Anticipated areas of focus will be real world location and orientation (including projection information) for CADD information and solving geometrical transformation from the GIS information to IFC information. The process will be documented and will be used as a recommendation for future work practices involving CADD and GIS Object translation.

Strategy support: Objective 4.1

Expected product: The information created will allow GIS software to read and correctly display IFC building information and to export topography information that would be accessible to IFC compliant CADD software. The process will be used in FY04 to create Object information for utilities that would be based upon the UML model resulting from the completed Utilities Model that combined the SDSFIE utilities data model with the Utilities model created from the joint project undertaken in FY03 by the Center and OGC.

Expected end date: End of FY 03

Implement Utilities Model in Object SDSFIE

Required resources: Nancy Towne, Barry Schimpf, and Warren Bennett

Specific instructions: This subgroup will extend the Utilities model developed by the Center and OGC in FY02 and produce an implementation of a Utilities Object Model. The model will include the water, gas, and electricity models that were produced in FY02.

Strategy support: Objective 2.1 & 2.2

Expected product: A demonstration of a utilities object model in a GIS software.

Expected end date: Summer 2003

Participate in Transportation Modeling

Required resources: Jack Huntley and Warren Bennett

Specific instructions: Mr. Bennett will continue to participate in the Transportation MAT meetings conducted by the OGC, FGDC, and DOT BST for the Roads, Air, and Transit domains. Mr. Bennett will distribute products of these efforts for review and analysis. Mr. Bennett will present the results of the CADD/GIS Center analysis at the domain meetings.

Strategy support: Objective 3.1 & 4.1

Expected product: Conceptual models of the domains having the requirements of the Center incorporated in the model.

Expected end date: 31 December 2002 (by direction of OMB) however, additional work to perfect the models after this first series of meetings is expected.

Implement Transportation Model in Object SDSFIE

Required resources: Nancy Towne, Barry Schimpf, and Warren Bennett

Specific instructions: This subgroup will extend the Transportation model developed by the FGDC, OGC, and other government and industry partners to produce an implementation of a Transportation Object Model. The model will include the roads, air, and transit models that were produced in late FY02 and early FY03.

Strategy support: Objective 2.1 & 2.2

Expected product: A demonstration of a transportation object model in a GIS software.

Expected end date: Late summer 2003

Develop a Hydrography Model

Required resources: Nancy Blyler and Jack Huntley

Specific instructions: This subgroup's efforts are linked to the FGDC Hydrographic effort with the geospatial one-stop activity

Strategy support: Objective 4.1

Expected product: A conceptual model of water transportation

Expected end date: Summer 2003

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Appendix E

Execution Plan

The basis, from which this plan's vision is derived, is the inability of current CADD/GIS technologies to interoperate and share data; to affirm that CADD/GIS data interoperability is ultimately needed by all AEC/FM operations; to project that data sharing and integration is probable in the next decade; and the commitment required to resource and fulfill this vision. As shown in the Figure 2 of the current state of data used in AEC/FM, conceptually, a typical data bin consists of project oriented data, with barriers to sharing with different systems, that is expensive to maintain, and difficult to consolidate.
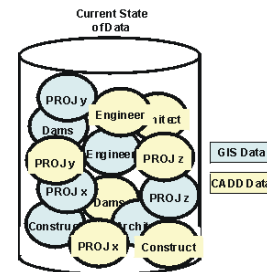
Figure 1 data states

The general consensus of professionals prior to the year 2000 was that CADD and GIS interoperability was "too hard", based on existing technological and communication capabilities. The CADD/GIS Center explored this issue with Intergraph, Bentley, AutoDesk, Graphisoft, and ESRI on how to solve the problem of CADD and GIS interoperability. The perceived market opportunities at that time did not exist which would allow industry to develop a rational business strategy to engage and solve this problem. This situation quickly changed around the FY00-01 timeframe, as a market for the CADD/GIS interoperable solution emerged from a growing user base looking for such a capability. Early on, there were attempts at a single-vendor solution, which proved to be inadequate to service the ever increasing need to exchange and share data among large corporations, and all levels of government. The demand for data interoperability between CADD and GIS systems is growing, and as a result, government and industry are working closely with standard organizations to breach this problem.

It is assumed that CADD and GIS objects, and the data they contain, have their greatest value when they exist within a common framework. The data is managed by the various functions of the business or engineering processes. In this state the data is adaptable for any project, regardless of the reason for their genesis. The data is sharable among many software systems, is inexpensive to maintain, and is easily consolidated. Figure 3 provides a conceptual representation of how the bin of data is transformed from the previous illustration of the current data state, to a fluid state, allowing the data to be available and used within a variety of systems, and for a greater number of uses than what they were originally developed for. The developers of CADD, GIS, and productivity software systems will utilize these objects for planning, analysis, or project management. The software systems will be responsible for any object/data conversion utilities that enable an efficient runtime format for their applications. As long as the data semantics, structure, and extents are preserved, and the standards they are assessed against are maintained, the objects can then be shared within a wide array of applications, and will be available for reuse.
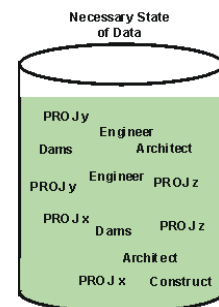
Figure 3 - Pool of data

The underlying approach toward achieving the long-term objectives of this vision is by defining and maintaining data semantics, an element of knowledge, through the implementation of an emerging new technology centered on the concept of ontology. At the center of this effort, is the ability to maximize the use of objects by tying together the "knowledge" of all objects through their inter-relationships. This is built through the development of statements that an ontological system can process. Objects, their inter-relationships, and their semantics enable assembly of an optimal set of objects, or parts of objects, which

satisfy an existing condition. An example is the assembly of the right objects and relationships in the form of equipment, personnel, and resources to address an emergency situation, such as a biohazard event. The ontological solution could also provide routes for egress and ingress. The general flow of activities to develop this ontological state is shown in Figure 4. Near term efforts will focus on UML coding of the existing SDSFIE, and the integration work with the FMSFIE, and the AEC CADD standard, to generate unambiguous languages in the standards, and then create an ontology registry from these cleaned standards. With these registries, interoperability will be achievable among disparate software applications such as for GIS and CADD systems.
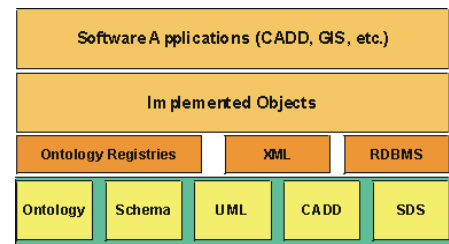
Figure 4 - A layered approach to interoperability

The execution plan contains parallel activity networks that synchronize for effective progression toward the vision. These four activities are 1) standards development and maintenance, 2) standards implementation, 3) demonstrating AEC/FM process improvement using the standards, and 4) the deliberate progression of standards implementation in COTS tools from data transfer, through data exchange, to data sharing.

1. Standards Development and Maintenance

The Center develops object standards for its customers by leveraging donated effort to the IAI for CADD standards and the OGC for GIS standards. Currently, the IAI has a more mature process and product than the OGC. The Center realizes that defining and investing into specific projects for these organizations to manage, will net the greatest benefit for the community. The Center will lead or be major contributors of these projects.

There are several issues concerning the IAI standards, which will need to be revisited often to assure the best solution for interoperability is achieved. The issues regarding this standard are the extent, or breadth of coverage of the IFCs; the hierarchal structure and its ability to be modified to keep pace with technology advances and with emerging new technologies; the ability to adapt new objects without dependencies on the existing IFC structure. The IAI has included industry in the test and evaluation of their standard, which has greatly enhanced the current utility of the IFCs. The OGC, in contrast, has not adopted any object standards. To overcome these deficiencies, the Center should:

1) Develop an object standards taxonomy to focus Center standards work,

2) Determine the content of IAI standards as it meets the expectations of the taxonomy,

3) Collaborate with the Center customers to determine taxonomy areas having greatest ROI,

4) Continue to work with the IAI to facilitate the changes needed to blend, adopt, or integrate the Center's taxonomy within the IFC's, and influence its future structure through the current memberships that the Center now supports, and

5) Continue to work with the OGC toward the development and implementation of an objects standard consistent with the Center's approach.

As standards are developed, a method of standards maintenance must be in place. This maintenance effort should alert standards development teams of existing standards, direct attention to evolving object standards that conflict with existing standards, maintain a repository of object standards accessible to all teams, establish a process for standards updates, and coordinate standards between CADD standards and GIS standards. It is imperative that the Center remains involved in the standards process, to influence emerging standards, introduce new standards, and to monitor the maintenance of existing standards, to assure that an environment is reached that will aid in the facilitation of data interoperability between

different systems and vendor platforms. At present, the Center is an obvious choice for this role. Funding the effort should come from sources that will benefit from the effort. Prime candidates for this funding are programs and initiatives that cross the CADD and GIS boundary (e.g., Department of State, Homeland Security, JPO Dahlgren, etc.). The Center should:

1) Build a conceptual model repository using a object standards taxonomy,

2) Integrate the IAI model into the repository,

3) Integrate the OGC models into the repository,

4) Provide the Center's resources as a demonstration site for IAI and OGC projects to both enhance the Center's physical capabilities, and to promote the knowledge and skill of its team members.

5) Create projects in the CADD and GIS standards organizations to describe interoperability within an area (e.g., a project that shows a utility supplied to a building),

6) Create a process for adding standard objects to the repository,

7) Create an access mechanism for standards development teams to use the repository, and

8) Create projects in the CADD and GIS standards organizations to build tools for automated compliance testing,

2) Standards Implementation Tools

Vendors implement CADD standards developed by the IAI. The Building Lifecycle Information Systems (BLIS) group is a confederacy of vendors that vow to implement CADD object standards in a reasonable manner and over a reasonable time. This term "reasonable" is based on expected ROI. Therefore, CADD and GIS standards implementation will need to demonstrate a market before the vendors will invest in new functionality.

If the current trend holds, the user community will implement GIS standards. The toolset developed by the Center SDSFIE project has proven to be beneficial to the users. Toolsets will need to be updated and expanded to meet the demand of the users and be transformed to address objects. With a consolidated CADD and GIS object standard, the GIS implementation toolset will need to interoperate with the CADD object implementation from software vendors.

Compliance to the standards has been a difficult issue for the SDSFIE and will have no-less importance with the object standards. The use of objects enables standard properties to be defined and inherited to user-defined objects. It is expected that compliance can be verified using object metadata, i.e. semantics about the object class and its properties, which would be produced as the user transfers content from one database to another.

The Center should remain the producer of standards implementation tools, as with the SDSFIE, and extend the toolset to include compliance testing tools for its object standards. Therefore, the Center should:

1) Develop rapport with BLIS and maintain information interchange to learn the IAI standards that will be supported by the vendors,

2) Provide the Center's resources as a test and evaluation site for BLIS projects to both enhance the Center's physical capabilities, and to promote the knowledge and skill of its team members.

3) Augment the SDSFIE toolset to access the object repository, instead of a tool database, and create a structure that can be read by the SDSFIE toolset,

4) Build a compliance checking tool,

5) Build a tool that enables users to enhance the standard as needed by their organization,

6) Augment the toolset to implement the various implementations used by GIS vendors and the Center customers,

7) Augment the toolset to access a Center web page for recommended standards changes,

8) Build a tool that converts legacy content to current object standard compliance.

3) Standards-based Processes

The Center consolidated object standards should be utilized to the utmost to demonstrate the importance and effects object standards have on engineering and business processes. The current engineering process includes contracting, value engineering, the design-build paradigm, design to cost requirements, and other issues that have not been able to use CADD software data. An object standard that changes the engineering work from a drawing based effort to a modeling effort should have an impact on the current construction business process. Geospatial placement of a structure and transfer of the model requires interoperability between CADD and GIS software. These capabilities should dramatically change the current contractual requirements and the means for inspecting construction progress.

Engineering and business processes use a combination of CADD and GIS software to perform each function. Functions in these processes require analytical and assessment tools that depend on vector data rather than raster data. This dependence on vector data reduces the significance of display symbology. Collaboration between functions and within functions requires sharing of data in the form of models rather than drawings. Drawings have been used as legal documents in contracts and construction delivery but these drawings are merely symbology in a form that depends on layers of data. Layer taxonomies tend to obscure information, as multiple layers are needed to display more comprehensive information. Vector oriented data should not be layered but this will require a new taxonomy for CADD and GIS data. To build these new processes, the Center should:

1) Classify the functions of the processes for which Center customers need assistance,

2) Identify the functions that would benefit from data sharing and/or collaboration,

3) Build scenarios for functions that use, or could use, CADD and GIS interoperability,

4) Demonstrate the extents of data interoperability between CADD and GIS applications, and

5) Broadcast information about the products that interoperate and assist with collaboration.

4) Achieving Shared Objects

The Center has worked with several standards organizations to develop object standards. Since the federal government has adopted the policy of using COTS tools rather than GOTS tools, Center customers rely on commercial software vendors to provide functionality needed to perform business functions. These software vendors are hesitant to invest in new functionality unless there is a market for it. Though the object approach offers significant advantages over procedural technology, vendors that have invested heavily in procedural technology will eventually recognize the value of adopting object technology, if sufficient market forces exist. If the market is not significant enough to warrant the transition, the vendor will ignore the pressure to maintain their market. The Center's strategy must account for the conservative approach of these vendors.

The Center's customers are already using COTS software tools. Using CADD as an example, Center customers have invested in particular vendor products. This investment includes hardware, software,

training, and expertise. Many customers will resist transitioning to object technology for the same reason as the vendors. Often, the customers that resist object technology will be using products from vendors that resist object technology, or using legacy systems that they have customized to satisfy internal needs.

The Center should approach the adoption of object technology as a migration rather than a instantaneous change. The Center should:

1) Identify and demonstrate engineering and business functions that rely on data transfer to promote the use of products that can export and import data,

2) Identify and demonstrate engineering and business functions that rely on multi-directional data exchange to promote products that can export and import reusable data objects,

3) Identify and demonstrate engineering and business functions that rely on shared data to promote products that can interact with a common database,

4) Identify and demonstrate engineering and business functions that rely on shared objects to promote products that can interact with a common object repository,

5) Identify and demonstrate engineering and business functions that require interoperation of a competitor's product features, usually through a toolbar icon, and interact without the use of export/import, a database, or a special repository (similar to the operation of productivity suites like Microsoft Office).

FY04 Work

Based on the successful completion of work enumerated in appendix D, the Center should plan to invest in each of the above areas in FY04. Each FY04 investment is described in the following paragraphs.

1) Standards Development and Maintenance
- The Center should begin development of a repository for object models. The repository should be a UML based tool that is used widely in standards organizations. The existing object models should be integrated into the repository.
- The Consolidated Object Standards taxonomy should be well defined and adopted by the Center. This taxonomy may need to exist in multiple forms. One form will display to the user community the development plan for the engineering and business areas, similar to the SDSFIE entity sets. Taxonomies are used to segment data enabling parallel efforts to define objects in the areas. The SDSFIE, FGDC, Geospatial One-Stop, USGS, and others define GIS taxonomies. CADD taxonomies, generally, use the engineering disciplines.
- The other form will display to the technical community the development plan of objects based on interoperable vector data. This vector data form enables that technical staff to plan the integration of the standards into the complete model. Rather than discriminate between levels or layers, used in the user-oriented taxonomy, this form enumerates items or object classes in a CADD and GIS model.
- The Center should initiate projects in both the IAI and the OGC that have a particular focus. There should be a project that combines the supply of each utility with the building model. Another project should be construction inspection using CADD and GIS objects.

2) Standards Implementation Tools
- The Center should develop rapport with BLIS and maintain information interchange to learn the IAI standards that will be supported by the vendors.
- The Center should augment the SDSFIE toolset to access the object repository, instead of a tool database, and create a structure that can be read by the SDSFIE toolset.

3) Standards-based Processes

- The Center should acquire information from its customers that indicate the engineering and business functions that would receive the greatest benefit from object technology.
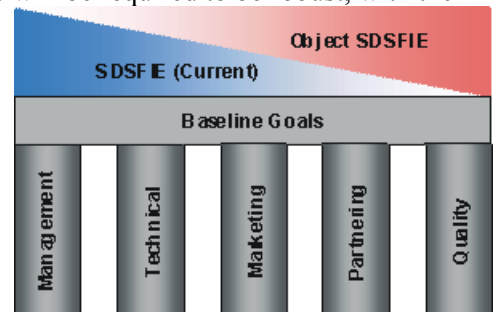
  Achieving Shared Objects
- Extend the current efforts between ArchiCAD and ESRI in the placement of building footprints, to the utilization of utility objects between the two systems.
- Identify and demonstrate engineering and business functions that rely on data transfer to promote the use of products that can export and import data,
- Identify and demonstrate engineering and business functions that rely on multi-directional data exchange to promote products that can export and import reusable data objects,

Future Work

It is necessary that the work done on the current CADD standards and the SDSFIE not be neglected, but maintained in support of current users of the standard. However, the highly structured model is based on themes, and is inflexible. The paradigm for the object standards will be required to be robust, with the structure built as a series of independent objects, and not theme oriented. This will assure adaptability of the objects for multiple uses, which is one of the most important attributes of the vision, and will amplify the value of an object standard. Figure 4 depicts efforts to both maintain, and eventually phase out the current SDSFIE, in favor of the developing new object oriented standard of the SDSFIE. The foundations of both efforts are the same, which are the five goals listed in detail in appendix A.

Figure 5 - The pillars of progress

The following table provides a broad view of the time execution of this. This only provides a global view of the planned activities to complete to fulfill the vision of this plan. The details associated with FY03's efforts are listed in Appendix D.

Table 1 - Timeline of the Object Standard Development

Year	Object Standards	Current SDSFIE, AEC CADD Standard, and FMSFIE
FY04	Object Standard Development • Share utility objects between CADD/GIS • Work on OCG Object standards consolidating transportation and land (from LandXML) • Facilitate Object standards sessions at the CADD/GIS symposium	Continued Improvements
FY05	Object Standard Development • Harmonize IFC's w/OGC objects • Consolidate cadastre and flora • Conduct missionary work on Object standards with users and government	Continued Improvements
FY06	Object SDSFIE development • Extend to homeland defense • Facilitate Object standards sessions at the CADD/GIS symposium	maintenance of standards
FY07	ISO standard submission • Submit ISO project to replace the SDSFIE standard	maintenance of standards
FY08	O-SDSFIE environment wk • Allow changes to reflect impacts of rain, heat, cold on objects • Update ISO standard • Facilitate Object standards sessions at the CADD/GIS symposium	phase-out of standards
FY09	Continued environmental wk • Extend the number of environmental conditions to impact objects • Update and maintain ISO standard	close-out of standards
FY10	Continued environmental wk • Impose compound impacts of environmental conditions on objects • Impose a time continuum of environmental conditions • Update and maintain ISO standard	

	• Facilitate Object standards sessions at the CADD/GIS symposium	
FY11	Developing dynamic features • Directional flow of materials such as water or waste • Update and maintain ISO standard	
FY12	Developing dynamic features • Extend direction or flow to other utilities in flow and direction, or electrical charges • Update and maintain ISO standard • Facilitate Object standards sessions at the CADD/GIS symposium	
FY13	Developing dynamic features • Allow for second order • Update and maintain ISO standard level of changes over a time continuum on objects	